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HYDROCHEMICAL INFLUENCES ON THE FISHERY WITHIN THE PHOSPHATE MINING AREA OF EASTERN IDAHO

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ABSTRACT

Hydrochemical analysis of selected streams in the upper Blackfoot River drainage showed waters in these streams were in a near-natural state, with possible modification from surrounding land uses. Stream hydrochemistry and physical condition of fish indicated the fishery was in good condition. No influences from present phosphate mining were found that threatened fish health or survival. Hydrochemically, the Blackfoot system is capable of producing a good cutthroat trout fishery, but high levels of nutrients probably restrict optimum cutthroat trout populations.

KEYWORDS: fish, water quality, heavy metals, surface mining, phosphate.

In 1977, 83 phosphate mining leases covered 43,370 acres (17,551 ha) of Federal lands in southeastern Idaho. The Bureau of Land Management (BLM) and the Forest Service (FS, USDA) have pending applications for additional mining leases. Lease approvals will result in applications for permits to build roads, conveyor systems, railroads, powerlines, dump sites, and communication sites.

A majority of the mine leases and potential mining sites are located on or near tributary streams of the upper Blackfoot River. Open pit mining operations in the study area have previously caused sediment and petroleum pollutants to enter Angus Creek[2], a

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[2]Platts, William S. 1970. Aquatic habitat studies in the Angus Creek drainage-Stauffer Mine pollution. USDA For. Serv., Intermt. Reg., Caribou National Forest, Pocatello, Idaho. 18 p.

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Blackfoot River tributary. Since this polluting period, progress has been made by the mining corporation toward containing mine-caused pollutants. However, the acceleration of surface phosphate mining throughout southeastern Idaho will eventually result in increased sediment in the streams and increased sediment transport throughout most of the upper Blackfoot system (G. Dennis Kelly, Forest Hydrologist, Caribou National Forest, Pocatello, Idaho, personal communication). The increased sedimentation will likely result in detrimental effects on aquatic life in the Blackfoot system.

From 1970 through 1976, general conditions of the aquatic environment and biota of the Blackfoot River drainage, including fish populations, were investigated to give baseline information for future assessment of mining impact in the drainage. The fishery and its relationship to environmental conditions other than hydrochemistry will be discussed in future reports. This hydrochemical study evaluated environmental changes, why they occurred, and the results of these changes. For the purposes of this study, a comparison was made of hydrochemical conditions and heavy metal concentrations in the area as compared to published findings on chronic and acute levels known to affect fish health.

Heavy metal-fish relationships are difficult to determine because elements other than well-known poisons have not been assayed as stressing agents on fish. Usually it is the quantity of the element as it relates (synergistically or antagonistically) to all the other solutes that determines its toxicity. Besides acute and chronic toxic levels, there are also tolerable and favorable levels of dissolved materials. For example, phosphate is an absolute requirement for all life, yet at high levels it can be detrimental to and cause mortality in fish.

STUDY AREA DESCRIPTION

The study area is located in Caribou County, Idaho, within the Soda Springs Ranger District (fig. 1). The study streams are in the Blackfoot River drainage, a major stream in the Caribou National Forest, Diamond Creek Planning Unit. The study streams drain watersheds encompassing past, present, and proposed phosphate mining that have and could in the future detrimentally affect the stream environments (Platts 1975).

The bedrock in the study unit is mainly Paleozoic and Mesozoic marine sediment composed of limestone, shale, sandstone, mudstone, and chert. The Phosphoria formation, an important member of the group, is the principal source of phosphate mined in this region. These substrates, rich in nutrients and other minerals, provide stream waters with the elements required for production of high aquatic biomass.

The study streams are mainly within the mountain valley bottomlands landtype that is nearly level to gently sloping, and tends to flatten out in the immediate stream vicinity. Streambanks have a high vegetative productivity potential and are often flooded during spring and early summer.

The mean annual precipitation varies from 20 to 30 inches (51 to 76 cm), mainly in the form of snow. Mean annual runoff is 10 inches (25 cm). The hydrochemical data indicated that surface waters are very fertile and when good physical habitat is present, high fish standing crops occur.

Fish populations in the drainage may be affected by irrigation diversions, degraded irrigation return flows, and intensive streambank grazing by livestock. In addition, much of the stream environment has been modified by beaver to form ponds.

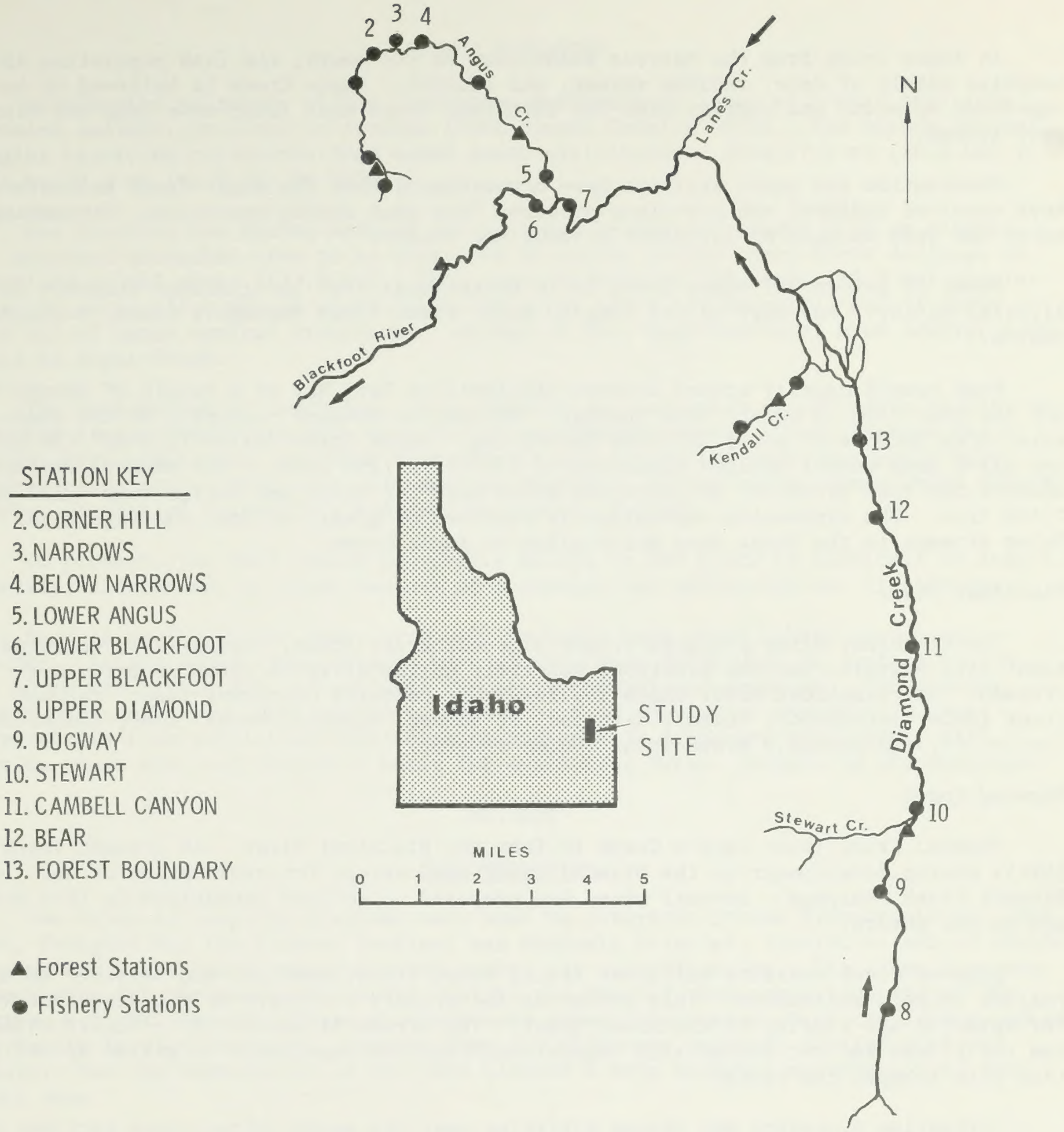

Figure 1.--Study streams and location of water sampling stations.

Study Streams

Angus Creek

Angus Creek contains cutthroat trout (*Salmo clarki* Richardson), one or two species of sucker (*Catostomus catostomus* Forester, *C. platyrhynchus* Cope), dace (*Rhinichthys* spp.), redside shiner (*Richardsonius balteatus* Richardson) and sculpin (*Cottus* spp.). The Angus Creek fish population from the downstream end of the narrows upstream to within 800 yards (730 m) of its headwaters is dominated by cutthroat trout. The upper 800 yards (730 m) of stream is barren of fish (1970-1976) except for a small, newly constructed reservoir where trout survival and growth has been excellent.

In Angus Creek from the narrows downstream to its mouth, the fish population is composed mainly of dace, redside shiner, and sculpin. Angus Creek is believed to be an important spawning and rearing area for cutthroat trout that later move into the Blackfoot system.

Observation and water analysis have demonstrated that the Angus Creek headwaters have received sediment and petroleum products from past mining operations. Streambank cover has been reduced by livestock grazing and beaver.

About 92 percent of Angus Creek is in bottomlands with low gradient channels in an alluvial valley. For part of its length, Angus Creek flows through a steep, V-shaped canyon.

Peak runoff usually occurs between mid-April to late May as a result of snowmelt, but the base flow is mainly from springs. Streamflow changes radically in the headwater area because of water diverted for mining. Angus Creek drains 13.9 mi^2 (36 km^2) and has a mean annual maximum discharge of 176 ft^3/s (299 cm/m). The channel averages about 6,500 feet (1,980 m) in elevation above mean sea level and varies from 6,397 to 7,100 feet. The streamside vegetation is composed of grass, willow, and sagebrush. Other streams in the study area are similar to Angus Creek.

Blackfoot River

The Blackfoot River produces trophy-size cutthroat trout. Trophy-size cutthroat trout also migrate from the Blackfoot Reservoir up the river to spawn in tributary streams. The Blackfoot River above the reservoir contains cutthroat trout, rainbow trout (*Salmo gairdneri*), sucker, dace, redside shiner, sculpin, brook trout, (*Salvelinus fontinalis*), and possibly brown trout (*Salmo trutta*).

Diamond Creek

Diamond Creek joins Lane's Creek to form the Blackfoot River. At present there is little mining development in the Diamond Creek area except for exploration on the Stewart Creek drainage. Several mines are proposed to go into production in this drainage in the future.

Diamond Creek contains cutthroat trout, brook trout, sculpin, and possibly dace, redside shiner, and sucker. This stream is the primary tributary of the Blackfoot River for spawning and rearing of cutthroat trout. The stream is inhabited by beaver which dam the stream and cut stream side vegetation; riparian vegetation is grazed by cattle that also trample the banks.

Irrigation diversion and stream splitting near its mouth, often cause portions of Diamond Creek to dry up during summer and fall.

Kendall Creek

Kendall Creek once drained into Diamond Creek, but has been diverted into Spring Creek. Kendall Creek is 3 mi (4.8 km) long and has an average channel gradient of 6 percent, which results in poor fish habitat in this reach. Below the Forest boundary, Kendall Creek flows onto the Diamond Creek valley and stream gradient becomes much lower.

The stream provides a minor spawning environment for cutthroat trout. Mining and livestock grazing have occurred within the Kendall Creek watershed, but upstream from the National Forest boundary these uses have little impact.

FUTURE SITUATION

Accelerated phosphate mining throughout southeastern Idaho will most certainly increase sediment delivery to streams (USDA Forest Service 1976). The stream channel lengths receiving pollutants from mined areas will increase from 17.4 mi (28.0 km) in 1976 to 39.7 mi (63.9 km) by 1999.

Ore location and mining methods will disrupt headwater streams. As an example, the proposed watershed area to be disturbed by mining in the Angus Creek drainage is comprised of 315 acres (127.5 ha). This area consists of 129 acres (52.2 ha) in mine pits, 85 acres (34.4 ha) in waste dumps, 89 acres (36.0 ha) in roads, and 12 acres (4.9 ha) of water control structures. Mining of this magnitude will have adverse influences on Angus Creek.

The combination of landforms, soil, vegetation, and water runoff often results in unstable stream conditions even when in the undisturbed state. Fish, through their evolutionary adaptation, maintain their health and population stability under most natural conditions. When land uses such as phosphate mining cause stress above natural levels, population instability and decline usually follow.

At present, the full impact of surface mining on the biota is difficult to detect, quantify, understand, or solve because of financial and methodological limitations.

Surface mining in the study area will probably have great impact on aquatic habitat. As mentioned, some streams have already been influenced by surface mining, but there are little data to evaluate the environmental consequences. The present report, in conjunction with following papers on fish population dynamics, macroinvertebrate-fish population relationships and aquatic structure conditions, will provide these data and furnish a basis for evaluating future changes in the drainage.

METHODS

Hydrochemistry

Two types of sampling stations were used to determine stream hydrochemistry. One type, designed for the fishery studies, was randomly selected, located on aerial photographs, and marked with numbered metal stakes for identification. The other type was selected to fit the needs of a water quality and quantity monitoring program of the Caribou National Forest. These stations were generally located where the stream crossed the Forest Service boundary. Samples from the different stations yielded similar results, but the combination of the data allowed a more accurate description of the study area.

Selected Forest Stations

Water sampling was done under the guidance of Dennis Kelly, Caribou National Forest Hydrologist, commencing in August 1974 and continuing monthly. Samples were collected at midstream, using a DH48 (Developed by Federal Interagency Sedimentation Project) depth-integrated sediment sampler. The sample was transferred to a plastic bottle, iced, and delivered to the Ford Chemical Laboratory, Salt Lake City, Utah, within 7 days after collection. Samples were analyzed within 7 days after arrival at the laboratory. Tests for water temperature, pH, and stream discharge were done in the field, and those for other parameters were performed in the laboratory.

Random Fishery Stations

Sampling commenced at these stations in the summer of 1970 and continued on a semi-regular basis through 1976. Samples were generally taken during high flow in May,

during the cutthroat spawning period in May and June, and during low summer flows in August. Some minor sampling was done on an intermittent basis over the remainder of the year. Water samples were collected at each station from riffle areas at middepth. Samples were collected in inert plastic bottles that had been stripped with acid and cleansed with hot distilled water. A 4-oz (114-ml) water sample was collected for heavy metal analysis, and a 16-oz (454-ml) water sample was collected for the remaining tests. For the heavy metal analysis the smaller bottle was acidified with 1 ml of HNO_3.

Samples were frozen and remained frozen until delivery to the laboratory. Samples were analyzed using standard methods at the Idaho Department of Health and Welfare Laboratory in Boise, Idaho.

Fish Tissue Analysis

Four cutthroat trout were collected at each random fishery station. The fish were placed in plastic bags, frozen, and later analyzed for tissue heavy metal concentration at the Idaho Department of Health and Welfare Laboratories in Boise, Idaho.

RESULTS AND DISCUSSION

Hydrochemistry

Results of analyses made on water samples collected from the streams during 1970-1976 are given in tables 1 through 4. These seasonal and mean values include samples collected by the Caribou National Forest, as well as those collected for the fisheries study.

Angus Creek

The mean alkalinity of 150 mg/liter, hardness of 142 mg/liter, temperature of 7°C, dissolved oxygen concentration of 12 mg/liter, and pH ranging around 7.5, when considered singly describe a good environment for a salmonid population (table 1). Levels of conductivity, total dissolved solids, suspended sediment and turbidity were within limits recommended by McKee and Wolf (1971) to support a good mixed fish fauna.

Analysis for phosphorus compounds demonstrated the high level of this element in the drainage. Mean values for dissolved (ortho) phosphate (0.11 mg/liter) exceeded levels which result in high biotic production in aquatic systems (0.01 mg/liter, McKee and Wolf 1971). These values exceeded the concentration of 0.05 mg/liter total phosphorus recommended as the higher level that should be allowed in streams flowing into lakes (Federal Water Pollution Control Administration 1968).

Total phosphorus in rivers of the United States usually ranges from 0.01 to 0.1 mg/liter. The Angus Creek value for orthophosphate is higher than this, but this may be a natural condition due to the geological nature of the drainage.

The moderate concentrations of nitrogen compounds (NO_3-N averaged 0.21 mg/liter) present may have been a limiting factor to game fish. The ammonia levels present were below those known to be toxic to aquatic life (2.5 mg/liter, McKee and Wolf 1971). The turbidity during spring runoff of Angus Creek (11 Nephleometric Turbidity Units (NTU)) is slightly higher than the recommended 10 NTU (FWPCA 1968). This may be due to the high amount of particulate matter in Angus Creek, which in turn is reflected in its high fertility. The majority of materials being removed from the watershed were in the form of dissolved solids (mean value 210 mg/liter).

The samples show an apparent seasonal trend, with values for parameters such as hardness, total alkalinity, and total dissolved solids increasing as waterflows decreased in the fall and winter. At the same time, values for suspended sediment,

Table 1.--*Seasonal and mean values for hydrochemical conditions in Angus Creek, a tributary in the Blackfoot River system, 1970-1976. Sample size in parentheses*

Season	Hardness	Dissolved oxygen	Total alkalinity	pH	Total solids	Total dissolved solids
	mg/l $CaCO_3$	*mg/l*	*mg/l* $CaCO_3$		*mg/l*	*mg/l*
Spring[1]	117		130	6.5-8.7	179	180
Summer	123		145	7.0-10.8	244	200
Fall	151		157	6.9-10.0	276	221
Winter	175		167	[2]N.T.	257	215
Mean	142(249)	[3]12(9)	150(233)	(51)	243(87)	210(236)

	Suspended sediment	Turbidity	Temperature	Conductivity	COD	Carbon total org.
	mg/l	*NTU*	*°C*	*mS/cm*	*mg/l*	*mg/l*
Spring	28	11.0	4	319	N.T.	N.T.
Summer	13	2.6	12	280	7.1	2.3
Fall	7	3.1	8	319	7.1	2.1
Winter	13	3.0	0.5	309	N.T.	N.T.
Mean	18(180)	7.6(254)	7(189)	318(180)	7.1(37)	2.1(17)

	P total	PO_4 Ortho (diss.)	NH_3-N	Total Kjeldahl-N	NO_3-N	NO_2-N
	mg/l	*mg/l*	*mg/l*	*mg/l*	*mg/l*	*mg/l*
Spring	0.19	0.37	N.T.	1.7	0.23	0.02
Summer	.25	.14	0.02	1.9	.18	.02
Fall	.14	.05	.03	1.7	.25	.00
Winter	.12	.12	N.T.	2.1	.16	.09
Mean	.22(253)	.11(68)	.02(17)	1.8(180)	.21(190)	.04(104)

[1]Spring: April, May
Summer: June, July, August
Fall: September, October
Winter: November-March

[2]N.T.:not tested

[3]Data available for D.O. are listed as a mean only; seasonal breakdown of values is not available.

turbidity, and nutrients generally decreased in conjunction with waterflow. Other parameters tested showed little or no change in value over time. These same trends are also generally the case for the remaining streams in the study area.

Blackfoot River

Hydrochemical values for the Blackfoot River were similar to Angus Creek (table 2), suggesting the river water provides a good environment for salmonids but possibly is too fertile for optimum conditions. The turbidity, chemical oxygen demand (COD), total organic carbon, and nitrate were significantly lower in the Blackfoot River than in Angus Creek. This may reflect a dilution factor in the larger stream, as well as less development in the Blackfoot River watershed above Angus Creek. Total orthophosphates in the Blackfoot River are higher than the recommended limits (FWPCA 1968; McKee and Wolf 1971).

Table 2.--*Seasonal and mean values for hydrochemical conditions from selected sites on the Blackfoot River, 1970-1976. Sample size in parentheses*

Season	Hardness	Dissolved oxygen	Total alkalinity	pH	Total solids	Total dissolved solids
	mg/l $CaCO_3$	*mg/l*	*mg/l $CaCO_3$*		*mg/l*	*mg/l*
Spring	142		145	6.5-8.8	197	198
Summer	155		149	5.6-7.2	280	239
Fall	154		183	4.8-8.4	288	208
Winter	201		188	6.5-7.7	246	230
Mean	144(117)	14(4)	155(113)	(30)	248(22)	211(57)

	Suspended sediment	Turbidity	Temperature	Conductivity	COD	Carbon total org.
	mg/l	*NTU*	*°C*	*mS/cm*	*mg/l*	*mg/l*
Spring	49	4.2	4	355	N.T.	N.T.
Summer	17	2.1	10	366	5.5	1.7
Fall	7	1.0	7	334	10.0	1.3
Winter	6	1.1	1.5	378	N.T.	N.T.
Mean	24(95)	2.2(125)	6(96)	352(95)	6.5(16)	1.5(8)

	P total	PO_4 Ortho (diss.)	NH_3-N	Total Kjeldahl-N	NO_3-N	NO_2-N
	mg/l	*mg/l*	*mg/l*	*mg/l*	*mg/l*	*mg/l*
Spring	0.21	0.09	N.T.	1.8	0.17	0.0
Summer	.18	.12	0.01	1.6	.13	.0
Fall	.18	.08	.02	1.9	.10	.0
Winter	.14	.11	N.T.	1.8	.10	.0
Mean	.20(117)	.09(36)	.02(8)	1.7(95)	.1(89)	.0(88)

Diamond Creek

Chemical analyses of Diamond Creek water samples were, in most cases, comparable to those for Angus Creek and Blackfoot River (table 3). Values for mean annual hardness, suspended sediment, COD, and Kjeldahl N were higher than in the Angus Creek and Blackfoot River samples, while total dissolved solids and conductivity decreased. All values when considered singly were well within the range for a good salmonid habitat. With a high mean dissolved phosphate concentration (0.11 mg/liter) and moderate nitrate level (0.15 mg/liter), Diamond Creek is a highly productive stream.

Kendall Creek

Chemical values for Kendall Creek were, in virtually all instances, less than for the streams previously discussed (table 4). A decrease in the average dissolved phosphate concentration (0.04 mg/liter) would probably result in less primary production in this stream. The Kendall Creek chemical environment is suitable for salmonids, although it may support a smaller fish density compared to other streams in the study area.

Table 3.--*Seasonal and mean values for hydrochemical conditions in Diamond Creek, a tributary in the Blackfoot River System, 1970-1976. Sample size in parentheses*

Season	Hardness	Dissolved oxygen	Total alkalinity	pH	Total solids	Total dissolved solids
	mg/l $CaCO_3$	*mg/l*	*mg/l $CaCO_3$*		*mg/l*	*mg/l*
Spring	129	N.T.	116	6.6-7.7	N.T.	188
Summer	180	N.T.	155	7.5-8.0	N.T.	192
Fall	177	N.T.	171	N.T.	N.T.	199
Winter	N.T.	N.T.	N.T.	N.T.	N.T.	N.T.
Mean	157(52)		148(52)	(30)		193(52)

Season	Suspended sediment	Turbidity	Temperature	Conductivity	COD	Carbon total org.
	mg/l	*NTU*	*°C*	*mS/cm*	*mg/l*	*mg/l*
Spring	95	11	3	295	N.T.	N.T.
Summer	36	4	9	293	3.3	N.T.
Fall	7	0.6	5	301	15.0	N.T.
Winter	N.T.	N.T.	N.T.	N.T.	N.T.	N.T.
Mean	48(52)	5(52)	6(96)	296(95)	8.0(24)	

Season	P total	PO_4 Ortho (diss.)	NH_3-N	Total Kjeldahl-N	NO_3-N	NO_2-N
	mg/l	*mg/l*	*mg/l*	*mg/l*	*mg/l*	*mg/l*
Spring	0.22	0.13	N.T.	4.3	0.24	0.0
Summer	.17	.10	N.T.	1.7	.13	.0
Fall	.14	N.T.	N.T.	1.7	.11	.0
Winter	N.T.	N.T.	N.T.	0	N.T.	.0
Mean	.17(49)	.11(11)		2.02(5)	.15(49)	.0(49)

Metals

Dissolved heavy metals, commonly found in waters polluted by industrial mining operations, have been confirmed as being toxic to the aquatic biota (Cairns and Scheier 1957; Lloyd 1960, 1961; Lloyd and Herbert 1962; Mount and Stephan 1967; Tarzwell and Henderson 1960). However, difficulty exists in determining the actual metal concentration that is toxic to fish.

Toxicity depends on the fish species (Lloyd 1960), water temperature (Chapman 1973), pH, dissolved oxygen concentration, total hardness, and other chemical parameters. In addition, metals and other elements may interact antagonistically to negate the toxicity of a metal in solution. In general, fish mortality results from exposure to excessive concentrations of a metal, while continuous low levels of a metal produce chronic effects such as behavioral changes, reproductive failure or fry mortality (Chapman 1973). Both ultimately affect the survival of a species in a stream.

Table 4.--*Seasonal and mean values for hydrochemical conditions in Kendall Creek, a tributary in the Blackfoot River System, 1970-1976. Sample size in parentheses*

Season	Hardness	Dissolved oxygen	Total alkalinity	pH	Total solids	Total dissolved solids
	mg/l $CaCO_3$	*mg/l*	*mg/l $CaCO_3$*		*mg/l*	*mg/l*
Spring	165		144	6.9-8.8	N.T.	204
Summer	115		112	7.9	N.T.	203
Fall	126		139	7.1-7.8	N.T.	201
Winter	163		159	7.3	N.T.	199
Mean	128(31)	13(4)	124(31)	(19)		201(26)

	Suspended sediment	Turbidity	Temperature	Conductivity	COD	Carbon total org.
	mg/l	*NTU*	*°C*	*mS/cm*	*mg/l*	*mg/l*
Spring	12	1.0	2	276	N.T.	N.T.
Summer	23	.8	6	312	2.3	0.8
Fall	11	11.0	5	300	5.3	.9
Winter	7	.5	4	163	N.T.	N.T.
Mean	13(52)	3.3(34)	3(25)	295(52)	3.7(6)	.9(6)

	P total	PO_4 Ortho (diss.)	NH_3-N	Total Kjeldahl-N	NO_3-N	NO_2-N
	mg/l	*mg/l*	*mg/l*	*mg/l*	*mg/l*	*mg/l*
Spring	0.12	0.05	N.T.	1.8	0.14	0.01
Summer	.08	.04	N.T.	1.5	.16	.01
Fall	.05	.03	N.T.	1.7	.23	.0
Winter	.06	N.T.	N.T.	2.0	.16	.01
Mean	.08(30)	.04(23)		1.8(6)	.18(27)	.01(27)

Heavy metal concentrations in the streams studied were generally quite low (table 5). Levels of iron in Angus Creek, Blackfoot River, and Kendall Creek (130-140 µg/liter) are approaching the toxic concentration of 200-1,000 µg/liter (McKee and Wolf 1971). When related to the buffering action of high hardness and alkalinity in the streams, these concentrations should have no detrimental effect on salmonids.

Chronic mercury toxicity usually occurs from 3-12 µg Hg/liter, while acute toxicity results from concentrations of 4-20 µg Hg/liter (McKee and Wolf 1971). Higher levels of mercury become tolerable as hardness increases. Mercury levels in Angus Creek, Diamond Creek, and the Blackfoot River are within an acceptable range, since in the hard waters of the study area readings up to 5.0 µg/liter probably have no effect on fish. However, mercury in the environment at these readings may be approaching levels that can be toxic to salmonids.

Any disturbance in the watershed may tend to alter the concentrations of any or all of these metals. In aquatic systems lead, zinc, copper, and cadmium are highly synergistic and can result in a combined toxicity greater than their individual concentrations (Chapman 1973). Since these metals are all present at detectable levels in the Blackfoot drainage, any increases in their concentrations might result in toxicity to fish.

Table 5.--*Concentrations of heavy metals in water samples collected from selected streams in the Blackfoot River drainage from 1970-1976 in μg/liter*

	As	Cd	Cr	Cu	F	Fe	Pb	Hg	Se	V	Zn
Angus Creek											
Mean	20	3.4	5.0	5.0	1.0	130	10	3.0	2.0	≤40	17
Min-max	0-10	0-280	0-10	2-16	0.09-0.17	10-65	10-10	2-3	0-10	0-70	2.8-25
85% C.I.[1]	0-50	0-5	1-10	1.2-12	0.6-3.0	90-270	10-10	2-3	0-5	3-41	10-25
Sample size	10	35	10	20	20	80	8	24	10	30	10
Blackfoot River											
Mean	2.0	4.0	4.0	4.0	1.0	130	10	≤2.0	2.0	≤50	10
Min-max	0-10	0-140	0-10	0-10	0.09-0.1	20-41	10-10	0.3-8	0-10	0-100	2-20
85% C.I.	0-5	0-5	1-6	2-8	0.6-3	120-300	10-10	5-6	0-5	0-60	6-16
Sample size	5	13	5	9	8	30	8	10	5	13	5
Diamond Creek											
Mean	2.0	5.3	3.0	3.0	0.1	[2]N.T.	N.T.	≤5.0	4.0	≤55	15
Min-max	0-10	0-240	0-10	2-4	0.08-0.12	N.T.	N.T.	5-9	0-10	0.0-100	2-30
85% C.I.	0-5	0-5	0.07-6	3-4	0.6-3	N.T.	N.T.	5.0-5.2	0.8-7	2-180	9-22
Sample size	5	26	5	5	23	N.T.	N.T.	21	5	26	5
Kendall Creek											
Mean	0.0	0.0	2.0	3.0	N.T.	140	N.T.	N.T.	0.0	0.0	10
Min-max	--	--	--	--	N.T.	140-140	N.T.	N.T.	--	--	--
85% C.I.	--	--	--	--	N.T.	140-140	N.T.	N.T.	--	--	--
Sample size	1	1	1	1	N.T.	6	N.T.	N.T.	1	1	1

[1]C.I. = confidence interval

[2]N.T. = not tested

Note: Heavy metal concentrations did not vary by season.

Fish Tissue Analyses

Table 6 lists results of chemical analyses for heavy metal concentrations in various fish tissues from the study area. In fish, the liver, kidney, and gills tend to concentrate and hold larger amounts of heavy metals than do most of the other organs.

In studies on the Clark Fork River of Montana, Van Meter (1974) found a mean concentration of cadmium in trout liver of 0.69 ppm by weight (μg/g). This concentration was generally above the 0.2-0.74 μg/g range found in fish from the Blackfoot River drainage (mean value for all samples was 0.44 μg Cd/g body weight).

The relatively high mean level of Zn found in the gills, 30.72 μg/g, indicates the tendency toward metabolic concentration of this element. Lloyd (1960) found Zn concentrates in the gills of fish, so high levels in this tissue were expected.

The results of the mercury analyses show a tendency toward concentration of the element in heart tissue. This trend appears to correlate with the slightly higher mercury levels found in the water (table 5), and differs from other studies that correlate tissue concentration with fish age (Potter and others 1975), length and weight (Scott 1974), condition (Hannerz 1968), or sediment concentration of the metal (Schroeder 1974).

Van Meter (1974) made similar findings in his Clark Fork studies, where mercury increases in the water were generally accompanied by increased concentrations in fish muscle. The higher vanadium concentrations in the liver may also be a result of this tendency. However, more detailed studies must be made before any definitive cause and effect statements can be made about the Blackfoot drainage.

Table 6.--*Heavy metal concentration (μg/g of body weight) in cutthroat trout tissues from the Blackfoot River drainage, 1976*

Collection location	Heart Hg[1]	Liver Cd	Liver V	Gills Cu	Gills Zn
Angus Creek Below Narrows	5.36	0.567	<4.7	0.445	26.5
Angus Creek Lower	<0.37	0.275	<4.6	<0.53	33.6
Angus Creek Two Pines	2.13	<0.2	<4.6	<2.3	23.5
Angus Creek Corner Hill	<0.76	0.474	<4.7	<1.38	28.5
Blackfoot River Lower	3.42	0.18	<3.9	2.66	22.2
Blackfoot River Upper	<0.67	<0.2	<4.7	3.76	45.1
Diamond Creek Upper	9.61	0.74	<4.9	<0.53	29.9
Diamond Creek Forest Boundary	4.52	0.49	<4.9	2.58	37.9
Diamond Creek Dugway	7.07	0.508	<5.0	<1.69	26.7
Diamond Creek Cambell Canyon	<0.33	0.56	<4.7	<0.66	24.2
Diamond Creek Bear Canyon	1.12	0.497	<4.5	0.669	33.8
Drainage average	2.82	0.44	4.55	1.52	30.72

[1]Recovery of a known concentration of mercury from tissue was 184 percent. Evidently a positive interference in the method resulted in the abnormal recovery. Therefore, realistic values for the samples might be 50 percent of the reported value.

Some authors have analyzed heavy metal concentrations in composite fish muscle samples (Lucas and others 1970; Uthe and Bligh 1971; Kelso and Frank 1974). This tends to make their average values lower than those found in analysis of specific tissues. Whole fish tissue analysis for copper (Kelso and Frank 1974), showed mean concentrations of 1.13 μg Cu/g dry weight. When comparing this value with the 1.52 μg/g average found in the Blackfoot drainage, it should be noted that this latter value is from gill tissue analysis, where the metal is probably more concentrated. Thus, the actual value for whole fish from the Blackfoot drainage based on the literature is probably lower than that of Kelso and Frank, and well within acceptable limits (0.7 μg 1.56 μg Cd/g whole body tissue, Kelso and Frank 1974).

SUMMARY

Hydrochemical analysis indicated that waters in the study area are in a near natural state, with possible modifications from surrounding land uses. No single parameter proved to be a major limiting factor in degrading fish health, lowering fish density, or adversely affecting fish community structure. Fish tissue analysis showed that no single metal was affecting fish health. Present mining activity does not appear to degrade water quality at this time. As hydrochemical conditions in this study are related to aquatic structure and streamside environments in companion studies, limiting factors may show up.

The Blackfoot River and tributaries are presently supporting a cutthroat trout fishery. However, we believe that the Blackfoot River, Angus Creek, and Diamond Creek are too fertile for a highly producing cutthroat trout fishery. Thus, any future land use that adds to this fertility could significantly depress the cutthroat trout fishery.

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